Gas Turbines and Microturbines for Distributed Energy Applications

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U.S. Department of Energy

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DEER Program Strategy

- Improve the efficiency and reliability of generation, delivery and end-use

- High-risk research
  - public/private partnerships
  - performance based programs

Program Portfolio

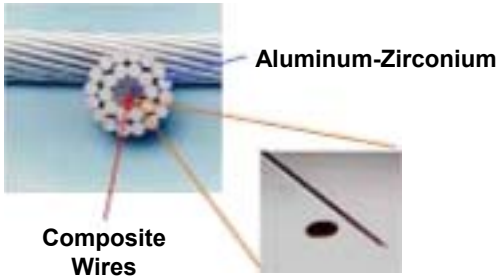
Fuel

Technology Development: **Microturbines, reciprocating engines, materials, storage**

Technology Packages: **Integrated CHP systems, chillers desiccants**

End-use Integration: Demand **Management, controls, sensors**

Composite Conductor



Electric and Gas Integration: **Load management, sensitive loads, power electronics**

Distribution Systems: **Load management, power parks, microgrids, HTS, storage, UPS, controls, DC grids**

Transmission System: **HTS, Wire materials, tools**

DER Funding Summary

($M)

Program Element	Fiscal Year 2003	Fiscal Year 2004 Request
INTERIOR		
Industrial Gas Turbines	5.0	3.0
Microturbines	7.0	7.0
Reciprocating Engines	12.0	9.0
Technology Base	8.26	8.26
Thermally Activated Technologies	7.66	4.66
Fuel Flexibility (oil)	0.750	0
Industrial DG/High Tech/Controls	8.34	7.34
Packaged Systems R&D/CHP	12.0	12.0
TOTAL INTERIOR	61.01	51.26
EWD		
Transmission Reliability		10.72
Distribution & Interconnection		7.25
Energy Storage		5.0
Superconductivity		47.8
TOTAL EWD	85.0	70.77

Distributed Gas Fired Technologies

Microturbines

2000
- $900-$1,200/kW
- 17-30% Efficiency
- Double digit ppm NO_x

2007
- Cost competitive with the market
- 40% Efficiency

2010
- Single digit ppm NO_x

"Prime Movers"

Gas Turbines

1992
- 29% efficiency
- Double digit NO_x
- $600/kW

2001
- 38% Efficiency
- Single digit NO_x
- $400/kW

2010
- Cost competitive with the market
- <5 ppm NO_x

Reciprocating Engines

2000
- $300-$400/kW
- 25-40% Efficiency
- 2-3 grams/kWh NO_x

2007
- Cost competitive with the market
- 50% Efficiency
- < 0.15 grams/kWh NO_x

Industrial Gas Turbines

2000

Today's ATS

- Low emissions technologies
- Advanced materials development

5 Low Emission Awards

- Precision Combustion Inc
- Catalytica
- Alzeta
- Solar Turbines
- Honeywell

4 Advanced Material Awards

- GE
- Teledyne
- Siemens Westinghouse
- Solar Turbines

(DOE funding $13M over 3 years)

2010

<5 ppm NO_x
Improved performance
< 10% cost add on
>8000 hrs durability

Low Emission Systems

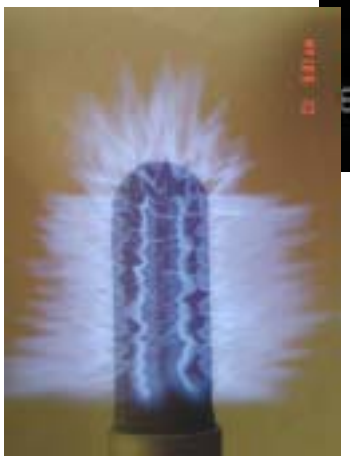
(Catalytic, Lean Premix and Surface Stabilized Combustion)

Catalytica ENERGY SYSTEMS

- Improve performance of Catalyst
- Solve system design problems
- Select optimal materials

PCI
Precision Combustion, Inc.

- **Robust**: No flashback / auto-ignition
  Tolerates fuel/air transients
- **Simple**: Air and fuel control
- **Multi-Fuel**: Natural gas, bio-based gas,
  and pre-vaporized liquids



ALZETA CORPORATION

Gas Turbine Combustor Liners

9 Field Installations - 2 sites

- More than 52,000 total hours of Operation
- Chevron/Texaco, Bakersfield, California
- Clemson University
  - Solar Turbines to start test of NIST/Siemens WE oxide ceramic composite outer liner at one of these sights – Q4FY03
- Malden Mills Industries, Lawrence, Massachusetts
  - Start test of GE PSC inner liner Q3FY04
  - Joint effort of Solar Turbines & GE
- Reduced Emissions:
  - Meets BACT in MA and Bakersfield without expensive water injection.

Ceramic Composite Shrouds in GE 7F Gas Turbine

MI-CFCC

HS-188

Benefits of Ceramic Composite

- Higher Temperature operation
- 1.1 % increase in turbine efficiency
- 3% higher output

- 4,000 to 8,000 hours validation test underway at Customer Site
- Shrouds look good after 537 hours of testing

Advanced Microturbines

2000

- 17-30% Efficiency (LHV*)
- Double digit ppm NO_x

Preliminary design 2001

FY00 – 6 Awards

- Ingersoll-Rand
- UTC
- GE
- Solar
- Honeywell
- Capstone

2007

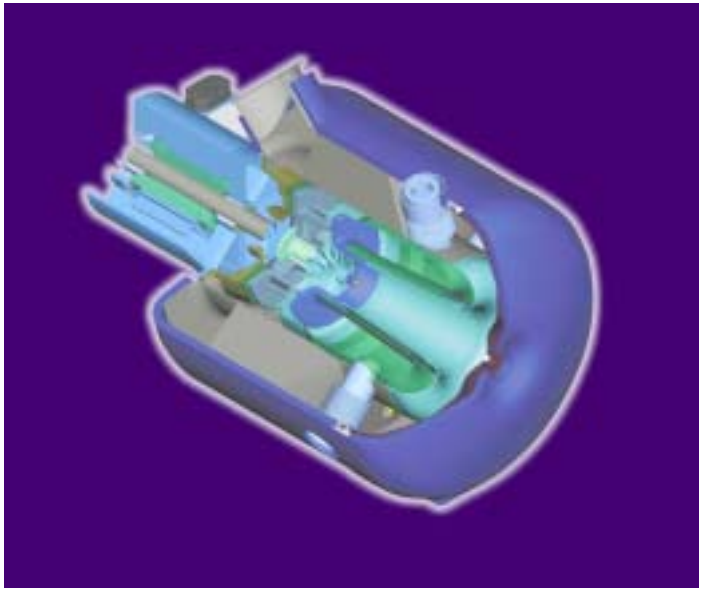
- 40% Efficiency (LHV*)
- Single digit ppm NO_x

** Lower Heating Value*

Ingersoll Rand /Capstone Highlights

Kyocera rotor for the 70 kWe CMT

- Kyocera silicon nitride ceramic rotor completed factory acceptance tests
- Engine tests are scheduled for 4QFY03
- Replacing the metal rotor with ceramic expects to gain up to 6% efficiency for (70KW)



- Testing of the C200 recuperated engine has commenced.
  - Metal baseline engine – up to 35% efficiency
- Two recuperator cores have been completed.

Advanced Microturbine Spin-offs

Organic Rankine Cycle Generator

Converts 250 to 750°F waste heat streams into 200 kW

Entering Field Demonstration

Organic Rankine Cycle Generator

Uses Exhaust from 4-60 kW Microturbines and prodiuces70 kW

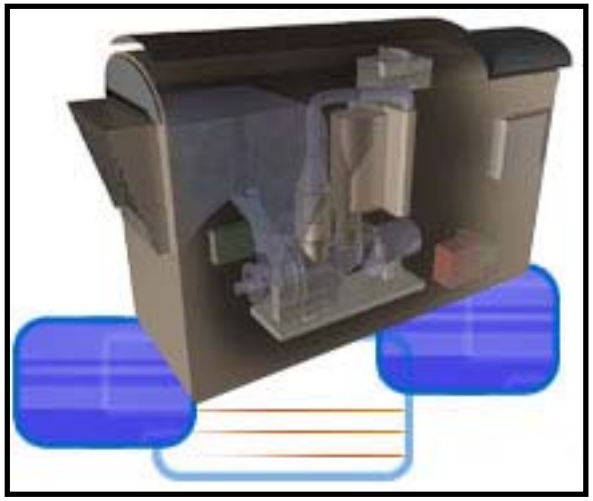
Increases Onsite Power Generation Efficiency by 30%

To be introduced 1st Quarter 2004

UTC Power
A United Technologies Company

Integrated Energy System (IES) Vision: Packaged System Integration

2002: Individually optimized products combined on-site



2010: IES - single optimized package from manufacturer

$19 Million Awarded For Integrated Energy Systems

- Seven industry teams have been selected for awards for research, development and testing of “First Generation” Integrated Energy Systems
- These Distributed Energy Resource (DER) systems are highly efficient with low emissions.
  - Allow small-scale (< 10 MW) power generation close to the point of use.
  - Combined with thermal recovery to heat or cool nearby buildings.
  - Improve energy security – electric reliability.
- More than 43% Industry cost-sharing (over $31 million total project costs).

Large Scale Modular IES

Honeywell Laboratories

5 MW turbine generator integrated with 1,000 RT waste-heat absorption chiller at Fort Bragg

Gas Technology Institute

Engine generator (290 kW to 770 kW) integrated with absorption chillers.

Burns and McDonnell

4.6MW turbine generator integrated with 2,000 RT of waste-heat and 500 RT of waste/direct fired absorption cooling with greater than 70% efficiency.

Small Scale Modular IES (30-600kW)

Capstone

30-60kW microturbines integrated with absorption chillers for space cooling in buildings

NiSource

Multiple microturbines integrated with absorption chillers, desiccant units, and control system developed as standardiz model for Hotel/Motel

Hilton

Industrial Partners Developing Small Scale Modular IES (30-600kW)

Ingersoll Rand

70kW microturbine integrated with ammonia-water absorption refrigeration for space conditioning and refrigeration

UTRC

-combination of off the shelf components for packaged system within 1 year

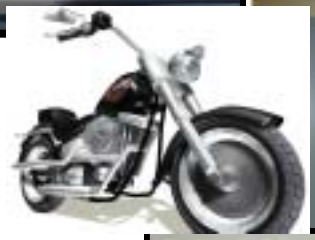
-Capstone 60 Microturbines coupled with Carrier absorption chillers. Also considering refrigeration, desiccants, and thermal storage systems

End-Use System Integration/Applications Program Objectives

- Facilitate acceptance of DER in end-use sectors
- Develop decision and design tools and conduct feasibility studies
- Demonstrate and quantify value to end-use customers (high efficiency, reliability, etc.)
- Document case studies for education and outreach

FAITH PLATING

DEMONSTRATION



Site:	Los Angeles, CA
Product:	Chrome plating shop
Cons. Utility:	Southern California Gas Company
Power Gen.:	Four 30 kW Capstone micro-turbines
Heat Rec.:	Hot water for plating tank heating
Operation:	base loaded
Status:	Data collection started June 2002
Comments:	Customer interested in using waste heat from the Unifin heater for sludge drying for maximum heat very – other plating companies interested

Russell Development Project

Site:	200 Market Street Portland, Oregon
Application:	General Office Building
Utility:	Bonneville Power Administration Northwest Natural Gas
Power Gen.:	Capstone 30
Heat Rec.:	Unifin Heat Recovery Heat Exchanger 10 RT Yazaki hot water activated absorption chiller
Operation:	Power for night/egress lighting. Exhaust used to produce hot water to drive absorption chiller.
Status:	Project commissioned September 2002.

HEB Supermarket

Site:	San Antonio, Texas
Cons. Utility:	City Public Service
Power Gen.:	Bowman/Elliott 80 kW microturbine
Heat Rec.:	50 Ton Broad Absorption Chiller
Operation:	liquid refrigerant sub-cooling to the low and medium temperature refrigeration racks
Status:	Site agreement in progress

Protocol Development for Lab and Field Testing of DER

- "Collaborative National Program for the Development and Performance Testing of Distributed Power Technologies with Emphasis on Combined Heat and Power Applications"
- Energy Center of Wisconsin, NYSERDA, CEC, Illinois DCCA
- Scope: Develop laboratory-testing, field-testing and case study protocols for gathering operational data on DER/CHP technologies and make information available through an internet-accessible database
- Project will emphasize environmentally beneficial combined heat and power applications of distributed generation technologies because of their great potential for increasing efficiency and reducing emissions

Upcoming Events

- **USCHPA Policy Day**
  - May 1, 2003 Washington DC
- **3rd Annual DOE/UN Hybrid Power Systems Conference**
  - May 13-15, 2003 Irvine, CA
- **DG/CHP for Federal Facilities**
  - May 13-14,2003 Irvine, CA
- **ASME TURBO EXPO 2003**
  - June 16-19, 2003 Atlanta, Georgia
- **4th Annual DOE-CETC-CANDRA Workshop on Microturbine Applications**
  - January 2004 in CA

For Additional Information

http://www.eere.energy.gov/der/